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Customers' Response to Electricity Price Variations caused by Intermittent Generation. An analysis of prices in Denmark[1].

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Abstract:

In thermal based electricity systems, increasing the share of intermittent production (mainly wind power) implies an increase in the volatility of marginal production costs. In liberalised electricity markets these variations are revealed in the market price and economists argue for exposing customers to the varying prices sending the right price signal. Getting customers to respond to short-term (hourly) price variations improve market efficiency, reduces price volatility, and a welfare gain is obtained. In addition, increasing demand response facilitates the integration of a large proportion of intermittent production. In periods with a large production from intermittent producers the price becomes low and a flexible customer will increase demand, and in periods with no intermittent production the price becomes high and demand decreases.

For customers to react on hourly prices three conditions are: a) metering of consumption at relevant time intervals, b) billing of consumption according to the marginal costs of production, and c) the ability and willingness of customers to change consumption. In addition, incentives for reacting on prices should be sufficient for customers to care. However, although long-term gains are evaluated to be substantial, short-term gains seen in the marked so far have been quite small and long-term gains are not very transparent for the customers.

In this paper, applying Nord Pool data for the two price areas in Denmark short-term effects and gains from customers reacting on hourly prices are evaluated.

Key words: Electricity market, Short-term demand response, Microeconomic analysis.
JEL classifications: Q41, D40, D61

1. Introduction

High targets for renewable energy related to EU´s energy and climate policy are expected to increase the proportion of intermittent production in the European electricity

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system. A characteristic of many intermittent energy technologies (especially wind) is the variability of production. In a thermal based electricity system, increasing the proportion of intermittent production is expected to increases the volatility of the marginal production costs, and in a liberalised market these costs are revealed in the market price. Economists argue for exposing customers to these varying prices, and hence, create a flexible demand that will help balancing fluctuations in supply, improve market efficiency, reduce price volatility, and create a welfare gain. However, to get customers to react on short-term (hourly) prices a number of challenges remain.

Using a simulation model for the Californian electricity market Borenstein (2005) calculates a significant long-term efficiency gain from hourly electricity pricing, mainly related to a reduced need for peak capacity. Customers, however, show some reluctance to observe and react to hourly prices. A number of explanations for this have been offered: costs of metering and billing, information costs and costs of changing consumption, wealth transfers among customers, and volatility of bills. In addition, short-term gains seen in the market so far have been quite small and long-term gains are not very transparent for the customer. Holland and Mansur (2006) develop a simulation model for the Mid-Atlantic electricity market PJM and calculate very small short-term gains. Looking at the Danish electricity system and using Nord Pool data for the period 2001-2008, in this paper average short-term welfare gains are evaluated to be quit small. However, being much smaller and having a larger proportion of fluctuating supply from wind power, the Danish electricity system is very different from the Mid-Atlantic market and gains vary considerable between years depending crucially on the variation in prices and the amount of fluctuating supply. That is, increasing the proportion of intermittent production increases price volatility and consumer benefits of flexible demand. In addition, in the future enabling technologies may make it easier for customers to respond to varying prices.

The remainder of this paper is organized as follows. Focusing on the Danish part of the Nord Pool market, the following section gives some characteristics of the electricity market and the Danish consumption and production of electricity. Section 3 provides a microeconomic analysis of demand response and develops the methodology used for the calculation of short-term welfare gains. Applying the methodology, short-term effects of demand response are reported in Section 4. Finally, conclusions are summarised in Section 5.

2. The Market for Electricity

Denmark is located at the border between the thermal system in continental Europe and the hydro power based system with considerable water reservoirs in the Nordic countries. The Danish electricity system itself is characterised as a thermal system with a mix of coal- and gas-fired plants, combined heat and power, and a large proportion of wind. On average, wind contributes about 20% of the Danish production and varies considerably. Finally, Denmark is part of the Nord Pool market and is divided into two price-areas (western and eastern Denmark) both connected to the Nordic and the continental European systems with fairly strong lines. That is, hourly electricity prices in Denmark are affected by the marginal costs of thermal production varying according to the marginal unit producing, considerable variations in the supply of wind, and storage of water in the Nordic hydro-power system. The possibility of water storage reduces the variation in hourly prices, but the effect varies between years depending on the amount of rain-/snowfall, and variation in the production from wind increases the variation in prices. In wet years the average price in the Danish area is low and the effect of varying production from wind is limited, while in dry years both the average price and the variation in hourly prices due to wind are high.

Looking at hourly variations in electricity demand and production, Figure 1 (left) shows the average hourly consumption for working days and weekends in Denmark and Figure 1 (right) shows the hourly production from wind turbines the second half of January 2007. Representing these hourly variations in a standard microeconomic scheme, Figure 2 (left) illustrates, that shifts in demand changes the position of the demand curve and implies a positive correlation between demand and the price. As changes in demand show a systematic daily variation, also price variations include a systematic daily variation. Figure 2 (right) shows that changes in the production form wind shifts the position of the supply curve and this implies a negative correlation between production and the price. As variation in production from wind is stochastic, prices include a stochastic negative correlation between production from wind and the price.

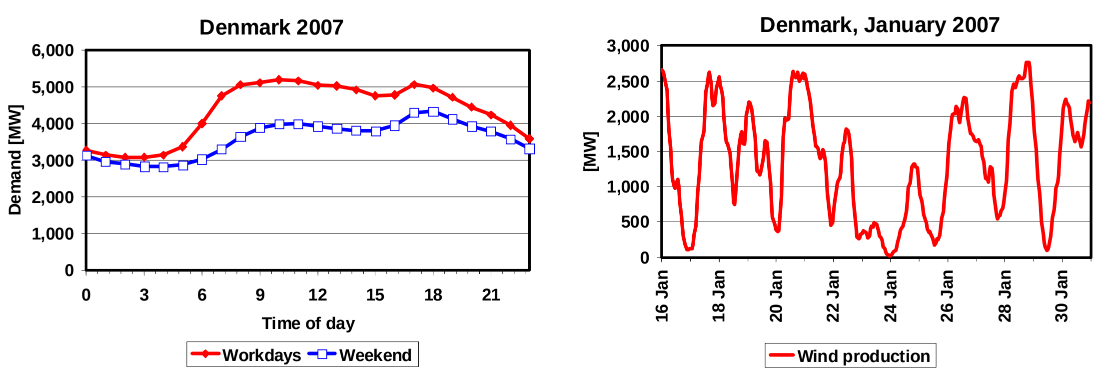

Figure 1. Average hourly consumption curve for Denmark 2007, and the variation of wind power production in the second half of January 2007.

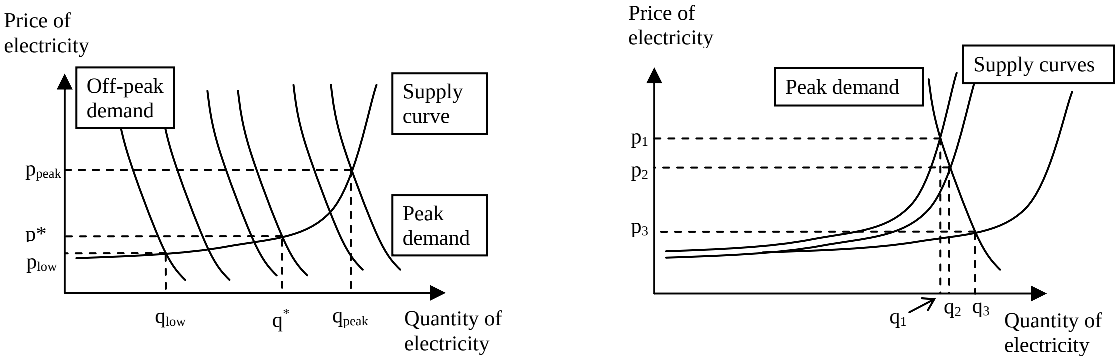

Figure 2. Effects of changes in the demand and supply of electricity.

Combining effects, and looking at a period with extreme variations in production from wind, Figure 3 shows the hourly consumption, the area price at Nord Pool, and at the lower part of Figure 3 the wind production relative to consumption for western Denmark the second half of January 2007.

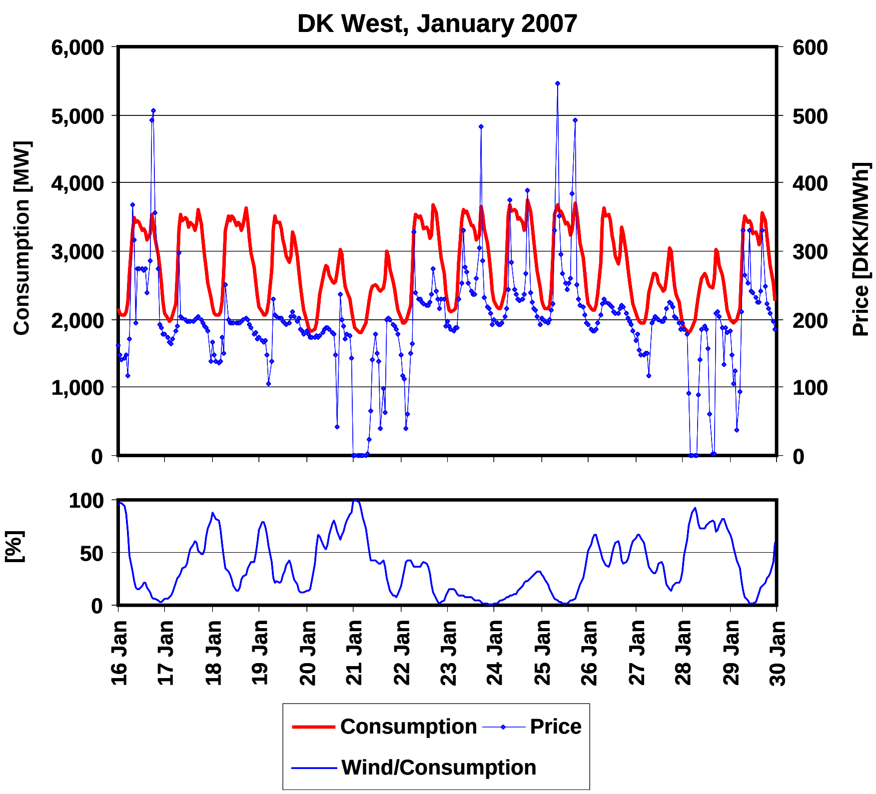

Figure 3. Hourly Nord Pool prices, consumption, and wind power production in West Denmark in the second half of January 2007.

Figure 3 illustrates a systematic positive correlation between the daily and weekly variation in consumption and the area price. Electricity prices are high during the day and low at nights and in weekends. On top of this Figure 3 illustrates an unsystematic variation where prices are high when production from wind is low and prices are low or even zero when production from wind is close to total consumption.

Descriptive statistics (average, average absolute deviation, and skewness coefficient[2]) for the period analysed is shown in Table 1. Quantities consumed in western Denmark is approximately 45% larger than in eastern Denmark, and comparing years, average hourly consumption and the average absolute deviation in consumption is almost constant over the years. Also, the relative average absolute deviation is almost the same for western- and eastern Denmark, and the distribution of hourly consumptions is almost symmetric giving a skewness coefficient close to zero. Prices are much more volatile. Comparing years and western and eastern Denmark, average hourly prices, average absolute deviation of prices, as well as the skewness coefficient vary considerably. In summary, the distribution of hourly quantities appears relatively stable, while the distribution of prices changes significantly over the years and differs for the two Danish price areas at Nord Pool. In general, the distribution of hourly prices has a positive skewness coefficient, indication that the distribution has a tail of high prices.

		Average		Average abs. deviation		Skewness coefficient	
		Price	Quantity	Price	Quantity	Price	Quantity
2001	DK West	24	2353	5	479	8.69	0.28
	DK East	24	1662	5	325	7.71	0.20
2002	DK West	25	2343	10	473	5.20	0.26
	DK East	29	1636	12	326	2.73	0.23
2003	DK West	34	2358	11	464	9.62	0.28
	DK East	37	1617	9	318	3.06	0.24
2004	DK West	29	2374	4	465	-0.36	0.25
	DK East	28	1623	4	318	0.28	0.22
2005	DK West	37	2398	11	476	4.85	0.23
	DK East	34	1642	9	315	34.52	0.18
2006	DK West	44	2443	10	468	0.09	0.26
	DK East	49	1664	12	316	2.24	0.20
2007	DK West	32	2465	12	471	11.92	0.23
	DK East	33	1657	12	309	13.42	0.19
2008	DK West	56	2461	15	467	0.72	0.20
	DK East	57	1649	17	305	1.08	0.15

Table 1. Descriptive statistics for observed prices [€/MWh] and quantities [MW] traded at Nord Pool 2001-2008.

[2] The skewness coefficient is calculated as: $E\left[(x-\mu)^3\right] / \sigma^3$. For a symmetric distribution the skewness coefficient is zero and for asymmetric distributions the skewness coefficient is positive if the long tail is in the positive direction. For a further description of the skewness coefficient see Greene, W.H. (1997) p. 66

3. A Microeconomic Analysis of Short-Term Demand Response

Showing one supply curve, a peak, and an off-peak demand curve, Figure 4 illustrates the short-term effects of changing from a fixed average price to hourly prices. Charging an average price (p_{avg}) customers demand electricity at points A or $\overline{A}$, the intersection of the horizontal price curve and their demand curves. This induces marginal production costs at points B and $\overline{B}$ and market prices of p_B and $p_{\overline{B}}$. Charging customers hourly prices an efficient clearing of the market is obtained in points C and $\overline{C}$ implying a lower price and quantity variation in the market and a short-term welfare gain equal to the shaded areas ABC and $\overline{ABC}$. In off-peak periods, electricity that has a value to the customer when priced according to its marginal costs is now consumed, and in peak periods an excess demand not valued the costs is foregone. The size of these effects depends on the shape of the supply and demand curves. Looking specifically at demand, the more flexible demand is (a less steep demand curve) the larger is the effect on the price, quantity, and welfare gain.

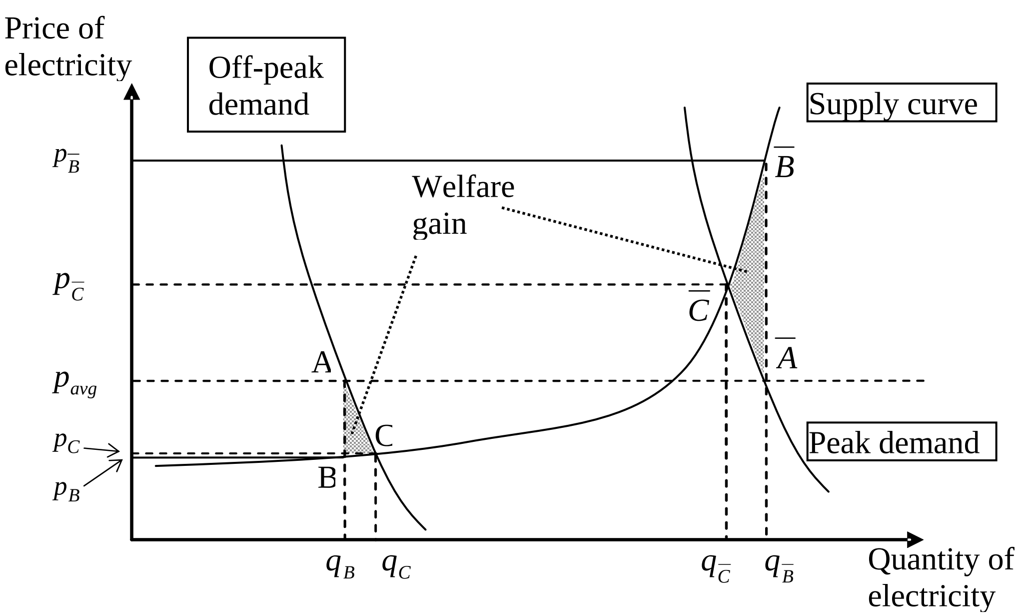

Figure 4. Effects of going from average pricing to hourly prices at the market.

In the Nord Pool day-ahead market, point $\overline{B}$ represents the hourly prices and quantities traded in the market, point $\overline{A}$ represents the average annual price paid by customers facing annual pricing. To calculate point $\overline{C}$ and the welfare gain the marginal properties of the demand and supply curves are required. In the calculations presented in the next section the curves are described by constant elasticity functions.[3] Finally, adding welfare gains for each hour of a year gives the annual welfare gain reported in the next section.

4. Short-Term Effects of Increased Demand Response in Denmark

Supply elasticities for the two Danish price areas at Nord Pool are calculated from the Balmorel model[4] and presented in Table 2. Concerning demand elasticities a sensitivity analysis with elasticities ranging from -0.05 to -0.5 is performed. Empirical studies of short-term demand elasticities vary between virtually zero and -0.4 and are in most cases estimated to be very small. However, in the future enabling technologies may increase the short-term price-elasticity of demand. A survey of empirical studies on hourly demand elasticities is given in U.S. Department of Energy (2006).

	Eastern Denmark	Western Denmark
prices below the average price	1,44	1,09
prices between the average and two times the average price	0,50	0,43
prices above two times the average price	0,21	0,13

Tabel 2. Price-elasticities of supply.

Two additional assumptions related to demand are:

- Customer prices are calculated from the Nord Pool wholesale price plus fixed average additions for subscription, grid-payment, and taxes. Customers are

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[3] Assuming that the marginal properties of the demand and supply curves are represented by constant elasticity functions, we have:

Demand: $\Delta \log(q) = \alpha \cdot \Delta \log(p)$ Supply: $\Delta \log(q) = \beta \cdot \Delta \log(p)$ [1]

where α , the price elasticity of demand, is a negative constant and β , the price elasticity of supply, is a positive constant. (It should be noticed that the assumption of constant elasticities is a local approximation and that the model valid for positive values of the price, only).

Inserting prices and quantities from Figure 4 into eq. [1] the equilibrium price and quantity at point C may be calculated as:

$$p_C = \frac{p_B^{\beta/(\beta-\alpha)}}{p_{avg}^{\alpha/(\beta-\alpha)}} \quad \text{and} \quad q_C = q_B \cdot \left(\frac{p_B}{p_{avg}}\right)^{\alpha\cdot\beta/(\beta-\alpha)} \qquad [2]$$

Finally, integrating over the constant elasticity equations, the welfare gain is calculated as:

$$w = \left(\frac{p_C \cdot q_C}{1+1/\beta}\right) \cdot \left[\left(\frac{q_B}{q_C}\right)^{1+1/\beta} - 1\right] - \left(\frac{p_C \cdot q_C}{1+1/\alpha}\right) \cdot \left[\left(\frac{q_B}{q_C}\right)^{1+1/\alpha} - 1\right] \qquad [3]$$

where the first part of the equation is the area under the supply curve going from q_B to q_C, and the second part is the corresponding area under the demand curve.

[4] A detailed description of the Balmorel model may be found in www.Balmorel.com

grouped in three categories with different fixed additives; households, small companies, and large customers. For households the additive is 196.4 €/MWh, for small companies 50.3 €/MWh, and for large customers 27.7 €/MWh. Fixed price additives act as a scaling factor on the price and reduce the relative price change. Therefore, assuming a constant demand price-elasticity, the corresponding quantity change is reduced.

- Each hour, each of the customer categories consumes one-third of the total consumption. On average, this is a reasonable approximation, but for individual hours this is a somewhat dubious assumption. Households consume a lower share of total consumption in normal working hours and a larger share in non-working hours and weekends.

For prices and the year 2007, Figure 6 shows the relation between the descriptive statistics of Table 1 and changes in the demand elasticity[5].

The main effect of introducing demand response is a considerable reduction in the volatility of prices and especially the tail of high prices is reduced (a considerable reduction in the average absolute deviation and the Skewness coefficient). Changes in quantities and the distribution of hourly quantities consumed are much smaller than for prices.

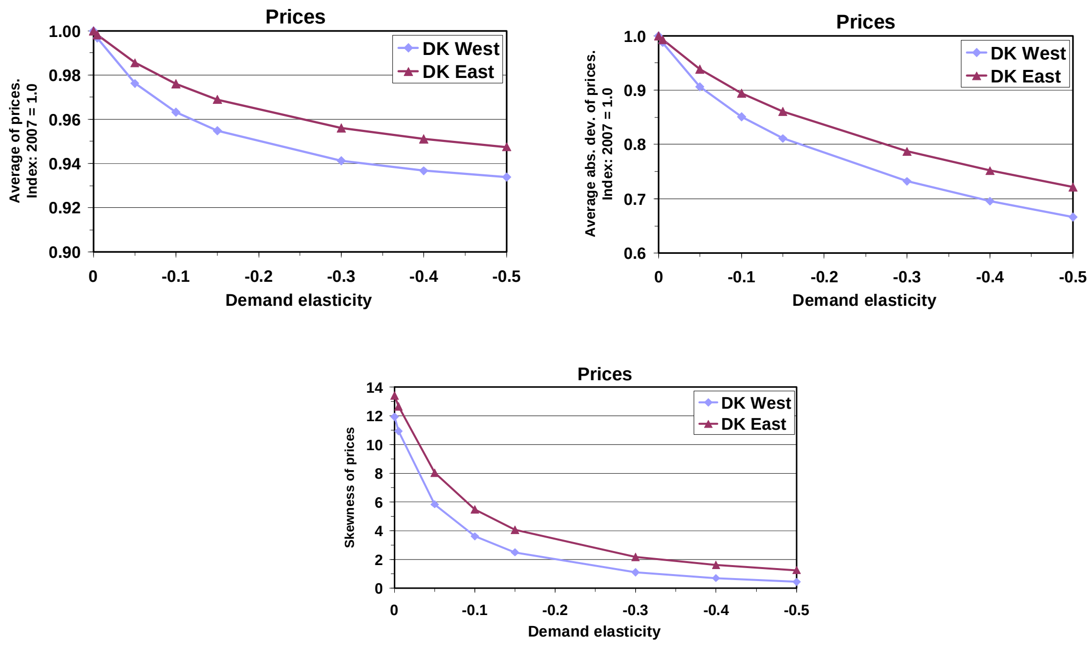

Figure 6. Demand price elasticity and changes in the average, the average absolute deviation and skewness coefficient for the distribution of hourly prices, 2007.

[5]The relation between the descriptive statistics and the price elasticity of demand for all years and both prices and quantities are given in Annex 1.

Combining price and quantity changes, short-term welfare gains for 2001 to 2008 are given in Table 3. In general, welfare gain increases with the numerical size of the demand elasticity, but the steepness of the curve decreases with increasing elasticity. The size of the short-term welfare gain is, however, quite small; assuming a large demand elasticity of -0.5, on average over the years 2001 to 2008 the total welfare gain is 12.9 M€ per year or less than 1% of the trade in the market. Due to grid payment, taxes etc. the welfare gain is less than 0.5% of what customers pay for electricity. Assuming a more realistic elasticity of -0.05, on average over the years analysed 2.1 M€ per year is gained.[6] This conclusion, related to the average welfare gain over the years analysed, is in line with conclusions in Holland and Mansur (2006). However, looking at individual years, Table 3 shows quite large differences in the annual welfare gain from one year to another. Annual differences are actually larger than the effect of a doubling of the demand elasticity. Doubling the demand elasticity from -0.15 to -0.3 increases the average gain by app. 70%, but annual gains vary a factor 6 to 7 from one year to another. To explain differences in annual welfare gains the distribution of hourly prices is important.

	Demand price elasticity												Average abs. dev. in Nord Pool prices			Skewness in Nord Pool prices	
	-0.05			-0.15			-0.3			-0.5							
	West	East	Total	West	East	Total	West	East	Total	West	East	Total	West	East	Total	West	East
2001	0.5	0.4	0.8	1.1	0.9	2.0	1.8	1.5	3.3	2.5	2.1	4.5	5	5	5	9	8
2002	1.2	1.1	2.3	3.0	2.8	5.8	5.0	4.8	9.7	7.1	6.8	13.9	10	12	11	5	3
2003	1.6	0.8	2.4	3.8	2.0	5.8	6.3	3.3	9.6	9.0	4.7	13.7	11	9	10	10	3
2004	0.3	0.1	0.4	0.7	0.3	1.0	1.3	0.6	2.0	2.1	0.9	3.0	4	4	4	0	0
2005	1.3	1.5	2.8	3.3	3.3	6.6	5.6	4.9	10.5	8.1	6.4	14.6	11	9	10	5	35
2006	0.8	0.9	1.8	2.4	2.5	4.8	4.3	4.4	8.7	6.7	6.4	13.1	10	12	11	0	2
2007	2.1	1.3	3.4	4.8	3.1	7.9	7.7	5.1	12.8	10.9	7.1	18.0	12	12	12	12	13
2008	1.7	1.4	3.0	4.5	3.7	8.2	8.2	6.6	14.8	12.3	9.9	22.2	15	17	16	1	1
Average	1.2	0.9	2.1	3.0	2.3	5.3	5.0	3.9	8.9	7.3	5.6	12.9					

Table 3. Short-term welfare gain [M€/year] assuming different price elasticities as well as average absolute deviation [€/MWh] and skewness in Nord Pool prices, 2001 to 2008.

Plotting the annual welfare gain against the average absolute deviation of hourly prices, Figure 7 shows that in general the welfare gain increases with increasing volatility of prices. However, welfare gains are not related to the average absolute deviation of prices, only, also the structure of the price variation is important. Looking at eastern Denmark, the welfare gain for 2005 is larger than for 2003 having a larger average absolute deviation in prices. Concerning 2005, 28 November the price peaked at 60 times the normal price, implying a very large skewness-coefficient. Leaving out the hours of

6 An elasticity of -0.05 implies that in an hour where the consumer price is twice the average, consumption is reduced by 5%. An average customer pays app. 90 €/MWh in grid payment, taxes etc. plus an average Nord Pool price of app. 40 €/MWh; in total app. 130 €/MWh. A doubling of the consumer price gives a price of 260 €/MWh equivalent to app. a 5 doubling of the NordPool price.

peak prices on 28 November the welfare gain for eastern Denmark 2005 is reduced about 30%. That is, a few very high prices contribute significantly to the welfare gain. Finally comparing years with the lowest and the highest welfare gain, 2004 and 2008, 2004 is characterised by a symmetric price distribution with a low average absolute deviation, and in 2008 prices were fairly volatile.

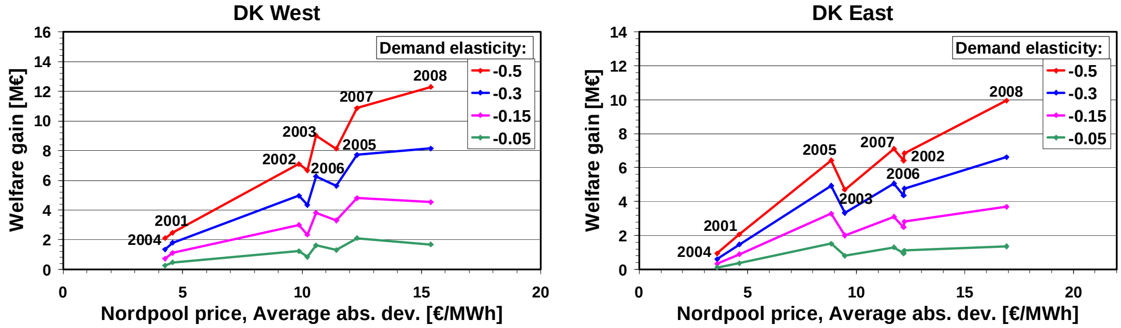

Figure 7. Annual welfare gains and volatility of hourly prices.

Looking at which parts of the price scale that contribute to the total welfare gain, for 2004, 2007, and 2008, Table 4 shows the welfare gain coming from prices below the average price at Nord Pool, between the average price and two times the average price, and above two times the average price.

	M€/year	Demand price elasticity											
		-0,05			-0,15			-0,3			-0,5		
		West	East	Total	West	East	Total	West	East	Total	West	East	Total
2004	Below average price	0,1	0,1	0,2	0,4	0,2	0,6	0,9	0,4	1,2	1,4	0,6	2,0
	Average to two times average price	0,1	0,0	0,1	0,3	0,1	0,4	0,4	0,2	0,6	0,6	0,3	0,9
	Above two times average price	0,0	0,0	0,0	0,0	0,0	0,1	0,0	0,1	0,1	0,0	0,1	0,1
	Total	0,3	0,1	0,4	0,7	0,3	1,0	1,3	0,6	2,0	2,1	0,9	3,0
2007	Below average price	0,6	0,3	0,9	1,8	1,0	2,8	3,5	2,0	5,5	5,7	3,2	8,9
	Average to two times average price	0,3	0,2	0,5	0,7	0,5	1,2	1,2	0,9	2,0	1,6	1,2	2,9
	Above two times average price	1,2	0,8	2,0	2,3	1,6	3,9	3,0	2,2	5,3	3,5	2,7	6,2
	Total	2,1	1,3	3,4	4,8	3,1	7,9	7,7	5,1	12,8	10,9	7,1	18,0
2008	Below average price	0,9	0,6	1,5	2,5	1,9	4,4	4,9	3,7	8,7	8,0	6,0	14,0
	Average to two times average price	0,6	0,5	1,1	1,6	1,2	2,8	2,6	2,0	4,6	3,6	2,9	6,4
	Above two times average price	0,2	0,3	0,5	0,5	0,6	1,1	0,6	0,9	1,5	0,7	1,1	1,8
	Total	1,7	1,4	3,0	4,5	3,7	8,2	8,2	6,6	14,8	12,3	9,9	22,2

Table 4. Contribution to welfare gain in 2004, 2007 and 2008.

For 2004, having a symmetric distribution of prices with a low average absolute deviation most of the welfare gain comes from prices below the average price. For 2007 where prices are more volatile and the distribution has a tail of high prices, assuming a low demand elasticity most of the welfare gain comes from prices above two times the average price. However, with an increase in the demand elasticity the contribution from prices below the average price increases more than the total gain and for very large demand elasticities more than 50% of the total gain is related to prices below the average price. Looking at 2008, having a symmetric distribution of prices with a large volatility, again most of the welfare gain comes from prices below the average price. That is, having a distribution of prices with a long tail of high prices even small demand price elasticities reduces the high prices considerably and this gives a large welfare gain. In symmetric distributions the number of prices above two times the average is small and most of the welfare gain is related to prices below the average price. Relating this result to the long-term welfare gains coming from a reduced need for peak capacity, even small demand price elasticities are important. However, to reduce the problem with zero – or close to zero prices related to periods with considerable amounts of wind, the price elasticity of demand has to become higher.

Finally, looking at the implication of fixed price additives (grid payment, taxes etc.), Table 5 shows the contribution from categories of customers. It is assumed that each hour, each of the customer categories uses one-third of the total consumption and the only difference between the three categories is the size of the price additive.

	M€/year	Price-addition €/MWh	Demand price elasticity											
			-0.05			-0.15			-0.3			-0.5		
			West	East	Total	West	East	Total	West	East	Total	West	East	Total
2004	Large consumers	28	0.1	0.1	0.2	0.4	0.2	0.5	0.7	0.3	1.0	1.0	0.5	1.5
2004	Small consumers	50	0.1	0.0	0.1	0.3	0.1	0.4	0.5	0.2	0.7	0.8	0.3	1.1
2004	Households	196	0.0	0.0	0.0	0.1	0.0	0.1	0.2	0.1	0.3	0.3	0.1	0.4
2004	Total		0.3	0.1	0.4	0.7	0.3	1.0	1.3	0.6	2.0	2.1	0.9	3.0
2008	Large consumers	28	0.8	0.6	1.4	2.1	1.7	3.8	3.7	3.0	6.7	5.5	4.5	10.0
2008	Small consumers	50	0.6	0.5	1.1	1.7	1.4	3.0	3.0	2.4	5.5	4.5	3.7	8.2
2008	Households	196	0.3	0.2	0.5	0.8	0.6	1.4	1.4	1.2	2.6	2.2	1.8	4.0
2008	Total		1.7	1.4	3.0	4.5	3.7	8.2	8.2	6.6	14.8	12.3	9.9	22.2

Table 5. Welfare gain and consumer categories (price additives).

A large fixed additive for households (in Denmark app. 6 times the average wholesale price) implies a low relative price variation, and therefore, a limited welfare gain from exposing households to varying prices. For large customers, paying a much lower additive (app. 100% of the wholesale price), the relative price variation is larger, and therefore, the welfare gain higher. The effect of the Danish price additives is that for households the welfare gain is less that half of the gain for large customers. The implication of this is that, to increase incentive for demand response, fixed price additives should be reduced or changed to a % type of additive. However, this implies uncertainty of revenue for grid payments, taxes etc. and in some cases fixed additives are introduced with the purpose of reducing the volatility of bills seen by the customers.

5. Conclusions

In a thermal system with wind, hourly costs and prices are very volatile. In a hydro-based system with large storage facilities, fluctuating wind resources may be balanced by hydro-storage and hourly prices are more stable. Introducing a large proportion of wind in the continental European system is therefore expected to increase price volatility and to require an increased demand flexibility, additional regulation and/or storage capacity.

Getting customers to react on fluctuating supply requires metering of hourly consumption, billing according to hourly prices, and the ability of customers to change consumption. Billing of hourly consumption according to hourly prices gives customers an incentive to change consumption. This incentive may not be very large, but given hourly metering, hourly pricing should be the default. Average pricing over longer periods implies a cross-subsidy form customers with a large consumption in cheap hours to customers with a large consumption in expensive hours and implies that customers have no incentives for responding to system needs.

Looking at demand response and the distribution of hourly prices, for even relatively low demand price elasticities the volatility of prices, and especially the tail of high prices, are reduced considerably. Average prices and quantities consumed and the distribution of hourly quantities consumed change marginally, only.

Considering short-term welfare gains, on average over the period 2001 to 2008 the potential gain seen in the Danish market is less than 0.5% of the electricity bill paid by customers (wholesale price plus grid payment, taxes etc.). That is, present incentives for increasing demand response are fairly limited. However, welfare gains vary considerably over the years, and gains increase with increasing volatility of prices and long tails of high prices.

The integration of a larger proportion of fluctuating wind power is expected to increase volatility of prices, and demand response facilitates the integration by balancing fluctuations in supply. Looking at welfare effects, the important effect of demand response is a reduction of demand at high prices and the need for peak capacity. However, if the distribution of prices is symmetric, very high prices are few, and a considerable share of the welfare gain comes from prices below the average price.

Given that long-term welfare gains are evaluated to be substantial, with short-term welfare gains seen in the market being small, to harvest long-term welfare gains additional incentives for increasing demand response are required. Looking at price-additives, for an efficient market fixed price-additives should be minimised and replaced by a percent-type of additives. This is important especially looking at the very high fixed price-additives (mainly taxes) placed on household consumption in Denmark. Finally, enabling technologies making it easier for customers to react on prices should be introduced.

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Annex 1. Effect of increasing demand response in Denmark.

		Demand price elasticity									
		0		-0,05		-0,15		-0,3		-0,5	
		Price	Demand	Price	Demand	Price	Demand	Price	Demand	Price	Demand
2001	DK West	24	316	24	316	23	316	23	317	23	318
	DK East	24	223	23	223	23	223	23	224	23	225
2002	DK West	25	315	25	315	24	316	24	318	24	321
	DK East	29	220	28	220	27	221	27	222	26	225
2003	DK West	34	317	33	317	32	318	32	320	32	323
	DK East	37	217	36	217	36	218	36	219	35	220
2004	DK West	29	319	29	319	29	319	29	319	28	320
	DK East	28	218	28	218	28	218	28	218	28	219
2005	DK West	37	322	37	322	36	323	36	325	36	327
	DK East	34	220	33	221	33	221	32	223	32	225
2006	DK West	44	328	44	328	44	329	43	330	43	332
	DK East	49	223	48	223	48	224	47	225	47	227
2007	DK West	32	331	32	331	31	333	30	335	30	339
	DK East	33	222	33	223	32	223	32	225	31	227
2008	DK West	56	330	56	331	55	332	55	333	55	336
	DK East	57	221	56	222	56	222	55	224	54	226

Table 1. Average hourly price [€/MWh] and consumption [MWh].

		Demand price elasticity									
		0		-0,05		-0,15		-0,3		-0,5	
		Price	Demand	Price	Demand	Price	Demand	Price	Demand	Price	Demand
2001	DK West	5	64	4	64	4	63	4	62	3	61
	DK East	5	44	4	43	4	43	4	42	4	41
2002	DK West	10	64	9	63	8	61	7	59	7	57
	DK East	12	44	11	43	10	42	9	41	8	40
2003	DK West	11	62	10	61	9	59	8	57	7	55
	DK East	9	43	9	42	8	41	7	40	7	39
2004	DK West	4	62	4	62	4	61	4	60	4	59
	DK East	4	43	4	42	3	42	3	41	3	41
2005	DK West	11	64	11	63	10	62	9	61	8	60
	DK East	9	42	8	42	7	41	6	40	5	40
2006	DK West	10	63	10	62	9	60	9	58	8	56
	DK East	12	42	12	42	11	41	10	40	9	39
2007	DK West	12	63	11	62	10	60	9	58	8	55
	DK East	12	41	11	41	10	39	9	38	8	36
2008	DK West	15	63	15	62	14	60	12	59	11	58
	DK East	17	41	16	40	15	40	14	39	13	39

Table 2. Average abs. dev. of hourly prices [€/MWh] and of quantities consumed [MWh].

		Demand price elasticity									
		0		-0,05		-0,15		-0,3		-0,5	
		Price	Demand	Price	Demand	Price	Demand	Price	Demand	Price	Demand
2001	DK West	8,69	0,28	5,85	0,27	3,41	0,27	1,94	0,27	1,06	0,28
	DK East	7,71	0,20	5,89	0,19	3,87	0,17	2,38	0,16	1,35	0,16
2002	DK West	5,20	0,26	3,07	0,25	1,73	0,23	1,04	0,22	0,63	0,22
	DK East	2,73	0,23	2,21	0,22	1,69	0,21	1,32	0,21	1,05	0,24
2003	DK West	9,62	0,28	4,88	0,27	1,91	0,26	0,53	0,24	-0,19	0,20
	DK East	3,06	0,24	2,65	0,22	2,07	0,20	1,52	0,18	1,05	0,17
2004	DK West	-0,36	0,25	-0,66	0,25	-1,01	0,25	-1,35	0,24	-1,68	0,24
	DK East	0,28	0,22	-0,18	0,22	-0,72	0,22	-1,18	0,23	-1,57	0,24
2005	DK West	4,85	0,23	2,58	0,23	1,26	0,25	0,67	0,29	0,34	0,36
	DK East	34,52	0,18	21,85	0,16	10,86	0,15	5,83	0,16	3,63	0,20
2006	DK West	0,09	0,26	-0,13	0,27	-0,38	0,29	-0,63	0,31	-0,88	0,34
	DK East	2,24	0,20	1,57	0,19	0,89	0,19	0,40	0,21	0,04	0,23
2007	DK West	11,92	0,23	5,84	0,23	2,49	0,22	1,10	0,24	0,42	0,26
	DK East	13,42	0,19	8,03	0,18	4,07	0,18	2,17	0,20	1,25	0,24
2008	DK West	0,72	0,20	0,32	0,22	-0,04	0,25	-0,31	0,30	-0,55	0,35
	DK East	1,08	0,15	0,73	0,15	0,36	0,18	0,08	0,22	-0,14	0,28

Table 3. Skewness coefficient for hourly prices [€/MWh] and consumption [MWh].